Hall-Jordan, Luke

From: Hall-Jordan, Luke
Sent: Monday, May 12, 2014 5:14 PM
To: 'Gallagher, Glenn@ARB'
Subject: RE: R-22 Data for California

Thanks, Glenn. I just wanted to make sure I was reading it properly. ☺

Talk to you soon,
Luke

From: Gallagher, Glenn@ARB [mailto:ggallagh@arb.ca.gov]
Sent: Monday, May 12, 2014 3:53 PM
To: Hall-Jordan, Luke
Subject: RE: R-22 Data for California

Luke,

Yes, I am stating that the stored amount is the amount banked in equipment in use, so the term "charged amount" or "amount currently in use in equipment" is a better description. (There is no estimate on the unused amount in inventory in my e-mail, hopefully, I did not communicate that incorrectly.)

I was using an estimated 10 percent annual leak rate against all equipment – very rough estimate, but the lower AC leak rates balance out the higher refrigeration leak rates.

Glenn Gallagher
ARB Research Division

e-mail: ggallagh@arb.ca.gov
phone: (916) 327-8041

From: Hall-Jordan, Luke [mailto:Hall-Jordan.Luke@epa.gov]
Sent: Monday, May 12, 2014 11:57 AM
To: Gallagher, Glenn@ARB
Subject: RE: R-22 Data for California

Thanks, Glenn, for taking the time to walk me through this today and for helping with my question last week. I have one additional follow-up question on this email. When you write "The annual emissions may represent only about 10 percent of the stored amount of R-22 used in refrigeration and AC systems in California. The stored amount of R-22 in California alone may therefore exceed 100 million pounds in use currently," you're referring to R-22 that is in use in existing equipment, not stored R-22 that is sitting unused in inventory, correct? It also appears you're assuming a 10% annual leak rate for all modeled equipment, correct?

Thanks,
Luke

Luke Hall-Jordan
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(202)230-7589 (c)

From: Gallagher, Glenn@ARB [mailto:ggallagh@arb.ca.gov]
Sent: Monday, May 12, 2014 1:00 PM
To: Hall-Jordan, Luke
Subject: FW: R-22 Data for California

Luke,

Here's the same e-mail sent to Mr. Williams of New Era Group, Inc.

Caveats on data: The following R-22 data is self-reported by distributors and reclaimers operating in California, and has not been verified for accuracy. ARB estimates that between 70 and 80 percent of all refrigerant distribution in California is being reported, but this estimate has also not been verified.

Data reported by Distributors Reporting in California			
Year	R-22 Purchased or received (lbs.)	R-22 sold or distributed (lbs.)	R-22 received and shipped for reclaim, re-use, or destruction (lbs.)
2011	6,859,511	7,386,352	277,283
2012	7,249,358	5,677,406	221,534
2013	4,722,116	4,484,304	352,920

Data reported by Reclaimers Reporting in California				
Year	R-22 Received by Reclaimers	R-22 Reclaimed in CA (lbs.)	R-22 Shipped out of CA for Reclaim (lbs.)	R-22 Shipped out of CA for Destruction (lbs.)
2011	185,283	120,839	90,820	820
2012	388,481	364,861	96,000	0 (zero)
2013	202,865	267,843	41,551	41,489

It is difficult to establish trends with only three years of data, however, we do see that the amount of R-22 received by reclaimers has decreased approximately 186,000 pounds, or 48% between 2012 and 2013. This decrease of R-22 received by reclaimers is greater than the decrease in purchases (-35%), and decrease in distribution (-21%). However, in the same timeframe of 2012 to 2013, the amount of R-22 shipped by distributors for reclaim did increase by 131,000 pounds, or 59%.

Further note that for all reporting years, the large difference between the amount of refrigerant distributed, and the amount recovered for reclamation. For example, in 2013, the total amount of recovered R-22 reported was approximately 556,000 pounds (distributors plus reclaimer reports), compared to 4.48 million pounds of R-22 distributed, indicating that almost 90 percent of refrigerant distributed is not recovered, and is assumed to be emitted.

Other R-22 estimated emissions in California.
Please note that R-22 emissions have also been estimated using an additional approach (other than sales and reclamation data reported to us) where we consider the many different sources of R-22. For the year 2013, we

estimate that approximately 11.7 million pounds of R-22 were emitted in California from commercial refrigeration and AC and residential AC, with a smaller amount (0.2 million pounds) from lesser sources, including bus and ship/marine vessel AC, and insulating foam. Using a global warming potential value (GWP) of 1810, this is equivalent to 9.8 million metric tonnes of carbon dioxide equivalents ($MMTCO_2E$). For comparison, the 9.8 $MMTCO_2E$ emissions from R-22 by itself represents 21 percent of all fluorinated gas emissions in California, and would be almost 2 percent of all GHG emissions in California (448 $MMTCO_2E$ total in 2011), if ozone-depleting substance emissions were included in the inventory, which they are not because ODS are phased out as part of the Montreal Protocol. For further perspective, 9.8 $MMTCO_2E$ in emissions is equivalent to the greenhouse gas emissions of:

1.3 million homes' electricity use for an entire year
2 million passenger vehicles for an entire year
Burning 1.1 *billion* gallons of gasoline
Burning 10.5 *billion* pounds of coal

Estimates from the U.S. EPA Greenhouse Gas Equivalencies Calculator at:
http://www.epa.gov/cleanenergy/energy-resources/calculator.html.

The annual emissions may represent only about 10 percent of the stored amount of R-22 used in refrigeration and AC systems in California. The stored amount of R-22 in California alone may therefore exceed 100 million pounds in use currently.

Hope this is useful. As I stated earlier, CARB does not have any official comment/outlook/position on the R-22 allocation at this time.

Glenn Gallagher
ARB Research Division

e-mail: ggallagh@arb.ca.gov

Hall-Jordan, Luke

From: Gallagher, Glenn@ARB <ggallagh@arb.ca.gov>
Sent: Wednesday, April 30, 2014 2:58 PM
To: Hall-Jordan, Luke
Cc: Whiteley, Elizabeth; Gupta, Pamela@ARB
Subject: RE: R-22 allocation questions (informal) from ARB staff

Sounds great, Friday May 2; at 12:30 ET/9:30 a.m. PT. Look forward to the invite and call.

Glenn Gallagher
ARB Research Division

e-mail: ggallagh@arb.ca.gov
phone: (916) 327-8041

From: Hall-Jordan, Luke [mailto:Hall-Jordan.Luke@epa.gov]
Sent: Wednesday, April 30, 2014 11:50 AM
To: Gallagher, Glenn@ARB
Cc: Whiteley, Elizabeth; Gupta, Pamela@ARB
Subject: RE: R-22 allocation questions (informal) from ARB staff

Hi Glenn,

I'll send an invite out separately, but how does 12:30 ET/9:30 PT sound?

Best,
Luke

From: Gallagher, Glenn@ARB [mailto:ggallagh@arb.ca.gov]
Sent: Wednesday, April 30, 2014 2:41 PM
To: Hall-Jordan, Luke
Cc: Whiteley, Elizabeth; Gupta, Pamela@ARB
Subject: RE: R-22 allocation questions (informal) from ARB staff

Luke,

Sounds great, my day is fairly open this Friday, except 11:30 to 1 Pacific time, which is 2:30 to 4:00 p.m. Eastern time. Also, we arrive at the office around 9 or so our time; noon your time. Other than that, the call can be at your convenience – let us know the time and number to call. My supervisor Pamela Gupta will also be on the call, her phone number is (916) 327-0604 if it's easier for you to call us.

Thank you,

Glenn Gallagher
ARB Research Division

e-mail: ggallagh@arb.ca.gov
phone: (916) 327-8041

From: Hall-Jordan, Luke [mailto:Hall-Jordan.Luke@epa.gov]
Sent: Tuesday, April 29, 2014 4:27 AM
To: Gallagher, Glenn@ARB
Cc: Whiteley, Elizabeth
Subject: Re: R-22 allocation questions (informal) from ARB staff

Hi Glenn,

Of course I know who you are. As soon as I get a free minute, I need to follow up on some of the leak data you've been collecting.

On the allocation, we haven't responded formally to any of the comments on the proposed rule, but will once the rule is finalized. As for how we chose the proposed options, the proposal lays out the rationale for each. There were three options (a 5-yr drawdown with equal reductions annually ending at zero; a 3-yr version; and the typical STR-driven estimation approach). If you'd like to discuss specifics, let's talk Friday.

Best,
Luke

Luke Hall-Jordan
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(202)230-7589 (c)

From: Gallagher, Glenn@ARB <ggallagh@arb.ca.gov>
Sent: Monday, April 28, 2014 4:28:51 PM
To: Hall-Jordan, Luke
Cc: Whiteley, Elizabeth
Subject: R-22 allocation questions (informal) from ARB staff

Luke,

Hello, I believe we have communicated previously on refrigerant matters, I work with the CA Air Resource Board's Refrigerant Management Program.

I realize there is a current rule-making process and a long history behind the determination of R-22 allocation levels, but was wondering if you could informally give me some information on how the allocation levels are determined. I have read the November 2013 "Servicing Tail" report on HCFC Phase-out by ICF and it looks like it is a good report that influenced allocation levels.

A stakeholder called us up with a concern that zero allocation of R-22 was warranted given the decreasing reclamation rates of R-22 (indicating reduced value of recovered R-22 from an apparent an over-supply), and the many anecdotal reports of R-22 stockpiling.

Wondering if maybe the EPA has addressed the requests for zero allocation already? I did not see any "Response to comments" yet on the docket page at:
https://www.federalregister.gov/articles/2014/04/07/2014-07718/protection-of-stratospheric-ozone-notice-of-data-availability-regarding-aggregate-hcfc-22-inventory

I am sure this is touchy issue and appreciate any insight you can share.

Thank you,

Glenn Gallagher
Research Division
California Air Resources Board

Phone: (916) 327-8041
E-mail: ggallagh@arb.ca.gov

Hall-Jordan, Luke

From: Hall-Jordan, Luke
Sent: Tuesday, May 20, 2014 3:04 PM
To: 'Jon Melchi'
Subject: RE: Meeting today

Sounds good. See you soon.

Luke

-----Original Message-----
From: Jon Melchi [mailto:jmelchi@hardinet.org]
Sent: Tuesday, May 20, 2014 2:38 PM
To: Hall-Jordan, Luke
Subject: Meeting today

Luke, it occurs to me I never told you what room at the liaison to meet us. You can meet us at metropolitan east/west. See you around 5. We should just be wrapping up. Best, Jon.

Hall-Jordan, Luke

From: Hall-Jordan, Luke
Sent: Monday, May 05, 2014 10:06 AM
To: 'Gallagher, Glenn@ARB'; Gupta, Pamela@ARB
Cc: Donaldson, David; Whiteley, Elizabeth
Subject: Concept note and slides from SNAP stakeholder meeting
Attachments: CAP SNAP Stakeholder Meeting_Presentation for Distribution_4 Feb 2014.pdf; Concept Note_SNAP Stakeholder Meeting_4 Feb 2014.pdf

Hi Pamela and Glenn,

It was great speaking with you on Friday. As promised, here are the slides from the SNAP Stakeholder Meeting. I've also included a brief summary below.

Summary:

On February 4, 2014 the EPA hosted a broad stakeholder meeting to engage in discussion on two proposed rule makings being developed in response to the HFC provisions of the Climate Action Plan. As part of the Climate Action Plan, President Obama directed EPA to use its authority through the Significant New Alternatives Policy (SNAP) Program "to encourage private-sector investment in low-emissions technology by identifying and approving climate-friendly chemicals while prohibiting certain uses of the most harmful chemical alternatives." The first proposed rule, a SNAP Low-GWP Refrigerants Rule, would expand the list of new climate-friendly alternatives for air conditioning and refrigeration applications. The second proposed rule, the SNAP Change of Status Rule, would propose to change the status of certain high-GWP HFCs where lower risk alternatives are available or potentially available.

Best,
Luke

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SNAP/Climate Action Plan HFC Component
Stakeholder Meeting February 4, 2014
Concept Note

Last June, President Obama announced the Climate Action Plan (CAP), and a broad set of initial steps designed to slow the effects of climate change. Among the many actions called for, the CAP outlined a set of measures to address hydrofluorocarbons (HFCs). In the United States, emissions of HFCs are expected to double from current levels of 1.5 percent of greenhouse gas emissions to 3 percent by 2020 and nearly triple by 2030.[1] HFCs are rapidly accumulating in the atmosphere. For example, the atmospheric concentration of HFC-134a, the most abundant HFC, has increased by about 10% per year from 2006 to 2012, and the concentrations of HFC-143a and HFC-125 have risen over 13% and 16% per year from 2007-2011, respectively.[2] [3]

In order to address HFCs, the President directed the United States to lead through both international diplomacy and domestic action. In particular, he directed the EPA to use its authority through the Significant New Alternatives Policy (SNAP) Program to encourage private sector investment in low-emissions technology by identifying and approving climate-friendly chemicals while prohibiting certain uses of the most harmful chemical alternatives. In addition, the President directed his Administration to purchase cleaner alternatives to HFCs whenever feasible and to transition over time to equipment that uses safer and more sustainable alternatives.

In August of last year, EPA held a broad stakeholder meeting to discuss the CAP provisions related to HFCs, and our initial thinking on how the longstanding SNAP program could be used to meet the President's goals. We also invited our stakeholders to share with us their ideas. EPA has held six sector specific workshops and a large number of individual meetings where stakeholders provided us with valuable input. Through those meetings, we have learned a great deal that will guide both our initial actions, and the longer term measures that we will consider in encouraging development, availability and widespread market acceptance of safer alternatives.

EPA would now like to share with our stakeholders what we have learned to date, and what we are considering by way of next steps. It is our hope that sharing this information at this time will provide a more specific roadmap to facilitate and focus the further input of our individual stakeholders, and that by laying out more detailed near-term plans, we can continue to gather and exchange information with you that can assist us in this process.

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[1] http://www.whitehouse.gov/share/climate-action-plan
[2] Montzka, S.A.: HFCs in the Atmosphere: Concentrations, Emissions and Impacts, ASHRAE/NIST Conference 2012
[3] NOAA data at ftp://ftp.cmdl.noaa.gov/hats/hfcs/

Specifically, at this point, we are planning two separate proposed rules – a rule expanding the list of low-GWP alternatives, which we expect will be proposed this spring, and a SNAP alternatives status change rule, which we expect will be proposed this summer. We expect that these rules will go through the full notice and comment rulemaking process, thereby enabling the Agency and other interested parties to benefit from your formal comments.

The new alternatives listing rule would address a group of key refrigeration and air-conditioning alternatives that we have been hearing about in our sector and individual meetings, and that have been submitted and reviewed under SNAP. This rule, if finalized, would enhance the SNAP menu of acceptable alternatives for a number of related end uses by proposing to add several alternatives as acceptable subject to use conditions. In keeping with our traditional review of the specific situation prevailing in each end use, this new listing proposal is likely to include a range of options, and could include lower GWP fluorocarbons, where such listings would decrease overall risk to human health and the environment. We expect that market acceptance of the newly listed alternatives will facilitate reductions in the use of high GWP HFCs and thus, advance the Climate Action Plan's goal of delivering significant climate benefits. Since SNAP lists are routinely relied upon not just domestically, but worldwide as a resource for transition, we further anticipate that this expansion will advance safer alternatives more broadly as well.

The second rulemaking, the SNAP alternatives status change rule, would respond to the President's direction for SNAP to prohibit certain uses of the most harmful chemical alternatives. We expect this status change proposal to prioritize opportunities with a view to enabling significant climate benefits.

We expect this rule to maintain SNAP's traditional pragmatic approach. Accordingly, stakeholders should not anticipate a broad review of all listings in this proposal; on the contrary, we intend to limit this proposal to what we believe are clear opportunities for reducing overall risk and securing climate benefits. Further, and as has historically been the case, our reviews will be done in a manner that is end-use specific, and, that does not rely on some preconceived 'bright line'. In that regard, we are aware that technological progress and market advances are profoundly case-specific. Hence, an alternative that is a comparatively high GWP HFC for one end use, may be very much in the middle of the pack for another end use. In developing this proposal, and consistent with our statutory requirements, we will also carefully consider the availability of alternatives, and, as in the past, we expect to make sure that we have a good understanding of the amount of time it might take to effectuate the conversion to available or potentially available alternatives. Finally, stakeholders may also anticipate that while we are responsive to the direction given us in the CAP, we will continue to consider not only effects on climate related to an alternative, but the full set of SNAP criteria as they pertain to a specific end use in making our decision for any substitute for that end use.

We are also aware of the various factors that individual stakeholders have raised for us to consider in prioritizing potential actions, such as the number and market penetration of available alternatives, diversity in the classes of alternatives available, the fact that different end uses may need different time periods to convert to new alternatives, and, their desire for EPA to consider allowing for the continued servicing of existing equipment in appropriate cases. Finally, we share the desire of stakeholders to find ways to enhance certainty for investments in low GWP technologies, and to increase the efficiency of EPA's review process.

Based on the information that we have gathered to date from the sector specific workshops and from our interaction with users and producers from around the world, we currently believe that there are lower GWP alternatives that are available or potentially available for certain end uses in the aerosols, foam-blowing, air conditioning, and refrigeration sectors. Accordingly, we have begun to look at individual end uses in these sectors and to focus on whether some high-GWP HFCs should no longer be acceptable. In that regard, and based on what we have learned to date, we currently believe that changes for some of the highest GWP HFCs currently listed as acceptable by the SNAP program in the following end uses may merit consideration:

- Non-Medical and non-technical aerosols
- Various foam blowing end uses
    - Rigid Polyurethane: Appliance; Commercial Refrigeration, and Sandwich Panels, Slabstock
    - Flexible Polyurethane
    - Polyolefin
    - Polystyrene: Extruded Boardstock & Billet
    - Rigid Polyurethane & Polyisocyanurate Laminated Boardstock
    - Phenolic Insulation Board & Bunstock
- Commercial Refrigerants: Vending Machines, Stand-Alone Reach-In Coolers, and Multiplex Supermarket Systems
- Motor Vehicle Air Conditioning

Given the situation currently prevailing in each of the end uses noted above, and in the context of an initial status change action, we believe that the menu of options would likely continue to include a broad range of alternative types (eg: both fluorinated and non-fluorinated alternatives and, in appropriate cases, chemical and not-in-kind alternatives.)

We appreciate the importance of your views, and the primary purpose of this concept paper is to share with you our current thinking to enable you to provide more focused input on these near term actions. In addition, the growing number of SNAP submissions attests to the dynamic nature of the affected industries, and the likelihood that

technological advancements will spur future SNAP/Climate Action Plan work. As a result, we would also appreciate the continued feedback of individual stakeholders on ways that we can optimize the operation of the SNAP program to meet the President's goal of reducing emissions of HFCs by, among other things, encouraging private sector investment in low emission technology.

SNAP Stakeholder Meeting

February 4, 2014

Welcome - Scope of Meeting

- The President's Climate Action Plan and HFC focal area
- SNAP principles and how they are being used consistent with the CAP
- Developing information on HFCs and alternatives
- Near-term roadmap and specific actions being considered
- Our questions for you – your questions for us
- Next Steps

What Does the President's Climate Action Plan Say about HFCs?

- Continue international diplomacy
  - Lead negotiations under the Montreal Protocol to phase down HFCs
    - Global phase down could reduce over 90 gigatons of CO2eq by 2050, equal to roughly two years worth of current global GHG emissions
  - Work with partners in the ***Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants*** to promote climate-friendly alternatives to high-GWP HFCs, address standards, and reduce emissions from HFC use
- Address through domestic actions
  - Use existing Clean Air Act authority of ***Significant New Alternatives Policy (SNAP) Program*** to approve climate-friendly chemicals, prohibit some uses of most harmful chemical alternatives
  - Provide federal leadership by ***purchasing cleaner alternatives to HFCs*** whenever feasible and by ***transitioning to equipment using safe, more sustainable alternatives***

EPA Immediate Next Steps

- Share information to facilitate and focus individual stakeholder input
- Currently planning two separate rulemakings
- 1) New SNAP Listing Rule
  - Would propose adding new low GWP refrigerants as acceptable subject to use conditions
  - Expected timing: proposed rule this spring
- 2) SNAP Status Change Rule
  - Would propose changing the status of certain high GWP HFCs
  - Expected timing: proposed rule in the summer

Some Key Principles Guiding Our Thinking

- SNAP rules will continue to consider individual end uses
- No across the board GWP cut offs
- No prohibition on HFCs as a whole, or in any one sector
- New HFCs or HFC blends may be listed if risk not greater than other available substitutes
- Recognition that timing is a critical dimension and that each end use has unique considerations
- Status change actions will be issued through notice and comment rulemaking

Other Factors Stakeholders Have Raised

- SNAP should continue its end use by end use and chemical by chemical approach
- SNAP should allow existing equipment be to be serviced to minimize stranded capital
  - EPA should consider the useful lifetimes of equipment
- EPA should consider mechanisms to add certainty to potential status change actions
  - Consider specific time periods for review and action
  - Consider percent of market already in alternatives
  - Consider minimum listing periods to enable recoupment of investment

What Has EPA Been Doing?

- We continue to evaluate new alternatives, develop sector specific characterizations, draft rules & notices
- EPA has been engaging with stakeholders:
  - August 2013: EPA held stakeholder meeting to discuss CAP's HFC elements and our initial thinking
  - 2013: EPA held six sector-specific workshops to exchange additional information on climate-friendly alternatives, potential transitions and data
  - EPA has also held numerous individual meetings
- EPA sought deeper understanding of the range of alternatives, ongoing transitions and where & why options are limited and more
  - Some views have been confirmed, & we have gained new information, insight

Low-GWP Refrigerants Listing Rule

- EPA is developing a proposed rule that would expand the list of low-GWP, climate-friendly alternatives for air conditioning and refrigeration applications
  - Add alternatives particularly where current options are limited
  - Since these refrigerants are flammable, EPA is planning to propose appropriate use conditions that adopt safety standards

Refrigerant	GWP	End Use and Application EPA is Considering					
		Household Refrigerators	Retail refrigerator stand-alone	Vending	Very Low Temp Ref	Heat Transfer	Home AC-Self-contained
Ethane	6				√	√	
Iso-butane*	8		√	√			
Propane*	3	√		√			√
R-441A* (HC blend)	<5		√	√			√
HFC-32	675						√

listed 12/2011 for other refrigeration applications

Change of Status Rule

- §612 directs EPA to list unacceptable substitute substances where there are other substitutes currently or *potentially available* that reduce overall risk to human health & environment
  - ***Potentially available:*** *adequate health, safety, & environmental data exist to make determination of acceptability, and EPA reasonably believes is technically feasible, even if not all testing has yet been completed and alternative is not yet produced or sold* (40 CFR 82.172)
- EPA plans to prioritize proposing to change the status of high-GWP HFCs where alternatives are available or potentially available
  - Proposed decisions being developed within existing SNAP framework and rely on established SNAP criteria
  - Considering end uses where low-GWP alternatives are available or potentially available
  - Considering end uses where significant environmental benefits can be achieved, backsliding to high-GWP HFCs avoided

Current Thinking on Possible Status Changes

- Consumer Aerosols (non-medical & non-technical aerosols)
  - Change status for HFC-134a, HFC-227ea and HFC-125
  - Retain HFC-152a
- Various foam blowing end uses
  - Change status by foam type, generally HFC-134a and higher GWPs
- Commercial Refrigeration
  - Vending Machines and Stand-Alone Reach-In Coolers
    - Change the status for HFC-134a and HFC blends with higher GWPs
  - Multiplex Supermarket Systems
    - Change the status for R-507A, R-404A and other HFC blends with high GWPs
    - Retain R-407A , R407F, others
- Motor Vehicle Air Conditioning
  - Change the status for HFC-134a

Open Dialogue – Questions and Answers

Open Dialogue –
creating the alternative

Hall-Jordan, Luke

Subject:	Meeting with HARDI
Location:	Liaison Hotel, 415 New Jersey Ave NW, Washington, DC 20001
Start:	Tue 5/20/2014 5:00 PM
End:	Tue 5/20/2014 6:00 PM
Recurrence:	(none)
Meeting Status:	Meeting organizer
Organizer:	Hall-Jordan, Luke
Required Attendees:	Donaldson, David; Whiteley, Elizabeth

HARDI members will be here for their Congressional Fly-in and their Refrigerants Council would like to talk with us about the HCFC Allocation Rule.

Hall-Jordan, Luke

Subject:	Call with EPA/CARB on HCFC Phaseout
Location:	We'll call ARB at (916) 327-0604
Start:	Fri 5/2/2014 12:30 PM
End:	Fri 5/2/2014 1:00 PM
Recurrence:	(none)
Meeting Status:	Meeting organizer
Organizer:	Hall-Jordan, Luke
Required Attendees:	Donaldson, David; Whiteley, Elizabeth; Gallagher, Glenn@ARB; Gupta, Pamela@ARB